5 Soil Composition

Chris knew that his class had watered the plants in the school garden and that they hadn't survived. He wondered if previous classes had watered their plants. Students in his class found a science notebook showing the watering schedule of two classes from the year before. They had watered the garden regularly, but their plants hadn't grown either. Chris thought there was enough air and sunlight in the garden. He decided it was time to find out more about soil.

CHALLENGE **What is the composition of soil?**

READING

When reading, answer the Stopping to Think questions in your mind. They can help you find out whether you understand the main ideas.

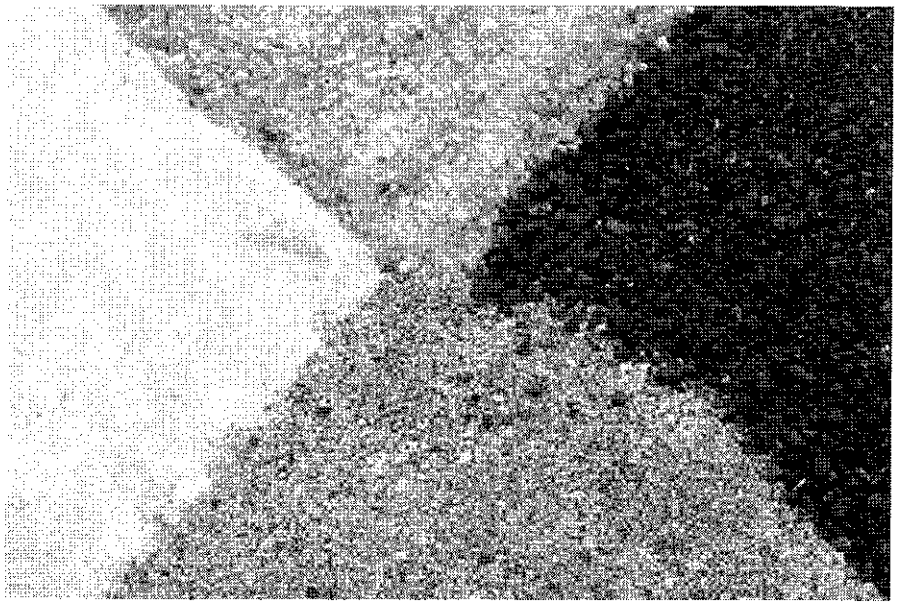
Weathered Rocks in Soil

All soil may seem alike, but soils in different places are different. One thing that all soils have in common is that they are mixtures of many things. Tiny pieces of rock are found in most soils. How do rocks become so tiny? Over time, rocks crack, crumble, and are broken apart by water and wind. Drops of water on a rock may repeatedly freeze and melt, causing the rock to crack. Water may react with some of the chemicals in a rock and cause part of the rock to wear away. Rocks sometimes fall from higher places, breaking as they fall and roll. All of this wearing down of rocks by natural forces is called **weathering.**

STOPPING TO THINK 1

The paragraph above describes three examples of rock weathering. Think of another example. Need help? Consider the different ways that water moves over the surface of the earth.

Scientists have names for the different-sized rocks found in soil. **Sand** is the word used for the largest pieces of rock in soil. Compared to rocks, sand is still very small, with the largest piece being less than 1/5 of a centimeter! Individual pieces of sand, or *grains*, are easily visible, but they are not as big as small pebbles.



Four different kinds of sand show a variety of grain sizes and compositions.

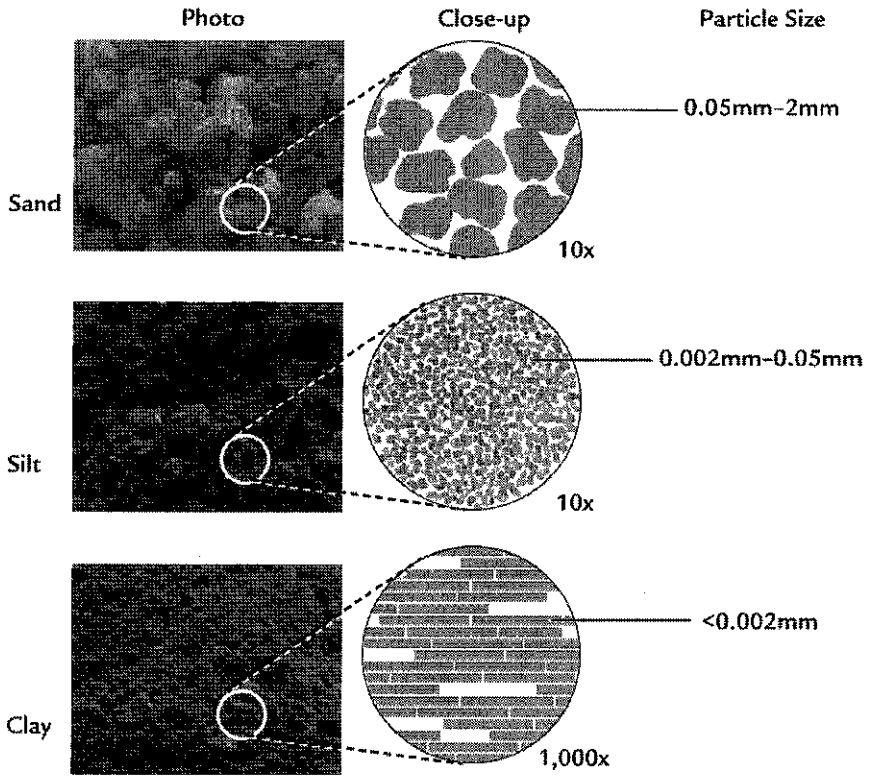
Pieces of rock that are smaller than sand are called **silt** and **clay.** Pieces of clay are so small they cannot be seen without a microscope. Pieces of silt are smaller than sand, but bigger than clay. You can compare the relative sizes of these rock pieces in Figure 1, "Comparing Rock Pieces" on the next page. Together, sand, silt, and clay are the main components of soil.

Soil from different places contains different amounts of sand, silt, and clay. For example, the soil from a desert may have a lot of sand in it. Soil scientists can often tell which part of the world a soil sample is from, based on the amount and type of sand, silt, and clay in the sample.

STOPPING TO THINK 2

A student examines some soil. She notices a small rocky piece that measures 1 millimeter (mm) across. Is this particle likely to be a rock, sand, silt, or clay? How do you know? Use Figure 1 on the next page to help you decide.

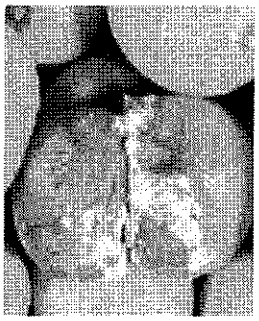
FIGURE 1: COMPARING PARTICLE SIZES IN SOIL



Organic Matter in Soil

Have you ever watched what happens to a very ripe piece of fruit that has been forgotten? It begins to change color, becomes soft, and starts to smell. It is **decomposing** (dee-kum-POZ-ing), or breaking down. If left outside on the ground, it will decay further until it is no longer recognizable as fruit.

Soil contains a lot of decomposed material. Fruit may fall to the ground and decompose to the point that it becomes part of the soil. The same thing happens to animal waste and to dead plants and animals that are not eaten by other animals. Decomposing plants and animals, including insects, leaves, and flowers, contribute to the **organic** (or-GAN-ik) **matter** in soil. The word "organic" refers to material from living organisms.



Bacteria and mold are decomposing these lemons.

As time passes, bacteria and other microorganisms help break down organic material into smaller and smaller particles that may look like dark brown clumps in the soil. Eventually, organic matter breaks down into basic chemicals. These chemicals, called **nutrients** (NEW-tree-unts), can dissolve in water and be absorbed by plant roots. The word *nutrient* comes from the Latin root *nutr-*, which means "to feed." Plants use nutrients produced from decomposing organic matter to grow. Organic matter is an important part of soil.

STOPPING TO THINK 3

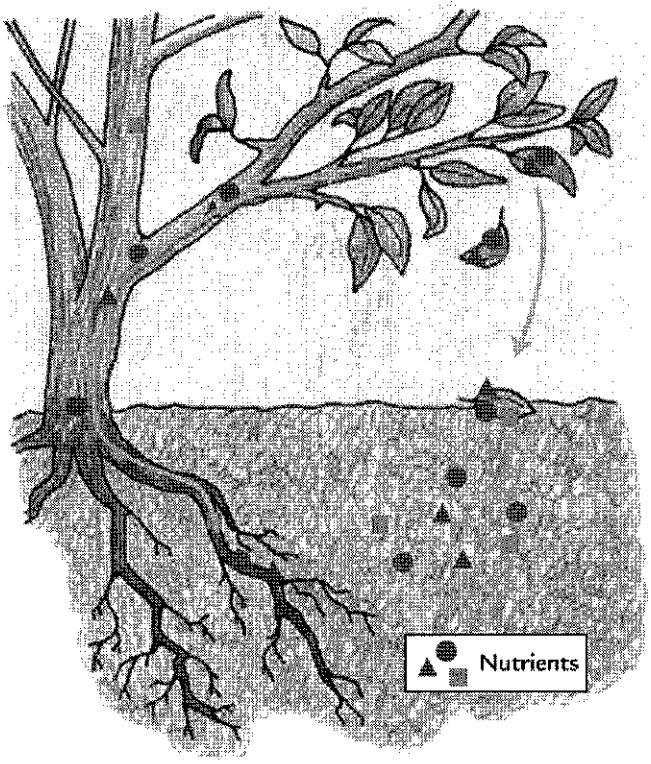
Why is it important for plants to grow in soil containing organic matter?

There can be different amounts of organic matter in the soil. In areas where many plants and animals live, grow, and die, there is more organic matter in the soil. Plants remove nutrients from the soil, but eventually they also give them back, as shown in Figure 2 below. When a plant dies, it may fall to the ground and decompose, adding to the organic matter (and the amount of nutrients) in the soil. This cycle of organisms living and dying helps enrich the soil with organic matter.

STOPPING TO THINK 4

How can a dead plant help another plant live?

FIGURE 2:
THE CYCLE OF
NUTRIENTS



Soil Layers

Topsoil is the soil in the uppermost layer of soil on the surface of the earth. It is the soil layer that you normally see, although it is only one of many layers. Each layer above bedrock has different characteristics. The different characteristics of each soil layer and bedrock are described below.

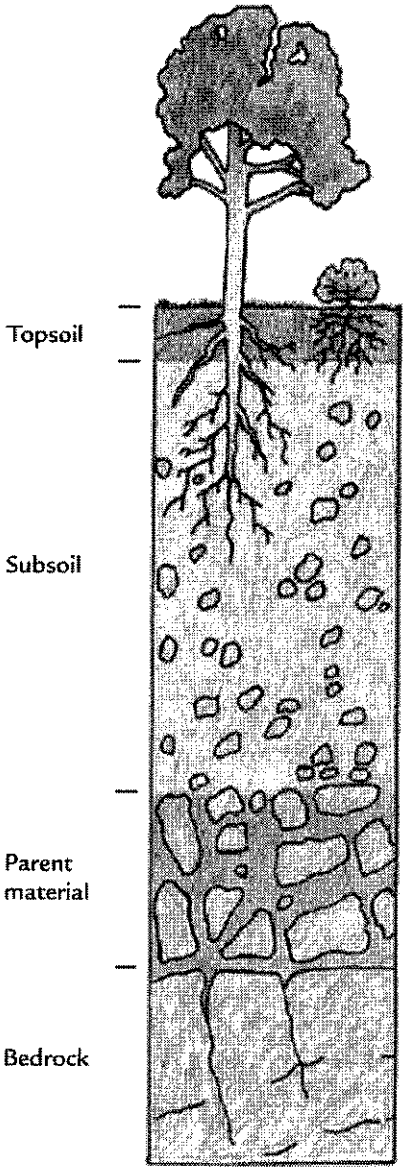


FIGURE 3:
CHARACTERISTICS OF SOIL LAYERS AND BEDROCK

TOPSOIL is a combination of rock, sand, silt, clay, organic matter, air, and water. Plants grow roots in this layer, which is rich with biological activity. Topsoil is about 20 centimeters deep, but it may be thinner or thicker depending on the location.

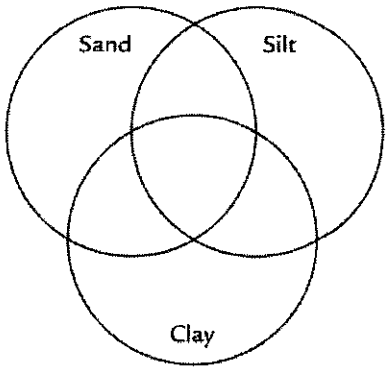
SUBSOIL contains some of the chemicals found in the topsoil as water drips from the soil above and washes these nutrients down. There is not much organic material in this layer.

PARENT MATERIAL is made up of slightly broken-up bedrock. Plant roots usually do not penetrate into this layer. Very little organic matter is found here.

BEDROCK is hard rock that lies beneath all the soil layers.

ANALYSIS

1. Create a larger version of the Venn diagram shown below. Record the characteristics of sand, silt, and clay in the circle with that label. In the spaces that overlap, record common features.



2. A dead leaf falls from a tree to the ground. If left undisturbed, what will happen to it?

3. Earthworms help organic matter decompose. In what soil layer do earthworms live? Explain your answer.

4. Look at your data on Student Sheet 4.1, "Soil Column Observations," from the last activity.

   a. Compare your data with what you now know about soil. Label sections of the soil column with words that you learned in this activity.
   Hint: Every section will not get a label.

   b. Which soil layer(s) did Soils A and B come from?

   c. Which soil, A or B, do you think is a better soil for gardening? Support your answer with evidence.

5. Look at your answer to Analysis Question 4 of Activity 3, "Observing Soil."

   a. Revise your answer to the question: *What is soil?* Write as complete a description as you can.

   b. Explain how your definition has changed since you began this unit.

6. What could be wrong with the soil in the school garden? Make a list of your ideas.

EXTENSION

Observe the decomposition of a piece of fruit. Find an appropriate place on the ground outside to place an old banana, avocado, or apple. (Remember that decomposing fruit may attract insects or small animals that help in the decomposition process.) Mark the area as a science experiment. Make observations every day for a few weeks and record your findings in your science notebook.

6 Describing Soil Scientifically

The next day, Ms. Clayson brought two bags of soil to class. One of the bags contained soil from the school garden. She brought it in so that the class could find out what might be wrong. The other bag contained soil from another garden in which plants were growing well. Unfortunately, she forgot to label the bags, and she couldn't tell them apart! She asked the class to help her figure out which soil came from the school garden.

Like the students in Chris's class, you will try to identify each soil by closely examining some soil characteristics. These include color, texture, and consistence. **Color** of soil can vary from grayish to yellow to deep red brown to black. **Texture** (TEKS-chur) describes the size of the particles. Rubbing soil between your fingers tests the soil's texture. **Consistence** (con-SIS-tens) describes how easily the soil clumps can be broken apart.

CHALLENGE **How do scientists describe soil?**

Scientists use a variety of tests to determine soil composition.

MATERIALS

For each pair of students

- **1 sample of Soil A**
- **1 sample of Soil B**
- **1 cup of water**
- **1 Soil Color Chart**
- **paper towels**

PROCEDURE

1. In your science notebook, make a table like the one below.

Table 1: Soil Observations

Soil Composition	Soil A	Soil B
Color		
Consistence		
Texture		

2. Compare the color of each soil with the Soil Color Chart. Record your observations in your data table.
3. Compare the consistence of the soils by trying to break apart a small clump of each soil. Record your observations in your data table.

   The soil consistence is

   loose if the soil breaks apart when held.

   friable if the soil breaks apart with a small amount of pressure from one finger.

   firm if the soil breaks apart with a lot of pressure between two fingers.

4. Compare the texture of each soil by wetting one finger and rubbing a little soil between your fingers. Record your observations in the data table.

   The soil texture is

   grainy if the soil is made up of large-sized pieces and feels gritty, like sand.

   silky if the soil is made of medium-sized pieces and feels powdery, like silt.

   sticky if the soil is made of small pieces and feels gummy, like wet clay.

ANALYSIS

1. Copy the lists of words shown below:

List 1	List 2	List 3
color	loose	rocks
brown	sticky	layers
red	consistence	organic matter
grayish	firm	cylinder
texture	friable	soil

   a. In each list, look for a relationship among the words. Cross out the word or phrase that does not belong.

   b. In each list, circle the word or phrase that includes the others.

   c. Explain how the word or phrase you circled is related to the other words on the list.

2. a. Read the following descriptions of soils.

SCHOOL YARD IN WARREN, MICHIGAN
In the southern part of the Lower Peninsula of MI, the soil color changes from gray to a gray-brown. There are more undecayed and partially decayed matter in the top layer of the soil. The soil also has lots of clay and a higher mineral content. Clays hold moisture better than sands and may be more fertile, but they tend to swell when they get wet, which may limit the movement of water and roots. Clays crack when they dry. This soil is found mostly in temperate humid and sub-humid regions of the world. The soil is a very productive soil for agriculture because it is rich in organic matter and nutrients.

SCHOOL GARDEN IN PHOENIX, ARIZONA
The soil is light brown to grayish. The consistence is firm because it takes some pressure to break apart small clumps. Its texture is gritty and sandy. The soil is found all over the southwestern United States, particularly in Arizona, New Mexico, and parts of Texas.

GARDEN IN ORLANDO, FLORIDA
This soil is a light to medium brown color. The consistence is friable because it falls apart with only a little pressure. With the exception of the twig particles, this dirt feels silky to the touch. The soil is rare in the United States, but can be found near the marshes of central Florida.

b. In your science notebook, make a table like the one below. Complete the table using the information from the descriptions of soils.

Table 2
Composition of Soils

Property	School Yard in MI	School Garden in AZ	Garden in FL
Color			
Consistence			
Texture			

3. Compare the descriptions of the soils from each garden to your observations of Soils A, B, and C.

a. Which soil is from the school garden in Phoenix, AZ? Support your answer with data & evidence from this activity.

b. Which soil is from the garden in Orlando, FL? Support your answer with data & evidence from this activity.

c. Which soil is from the school yard in Warren, MI? Support your answer with data & evidence from this activity.

4. The best soil for plants in the school garden is a dark, silky soil that is loose or friable. Which would be better for the school garden – Soil A or B? Explain.

7 Mapping Soils

INVESTIGATION

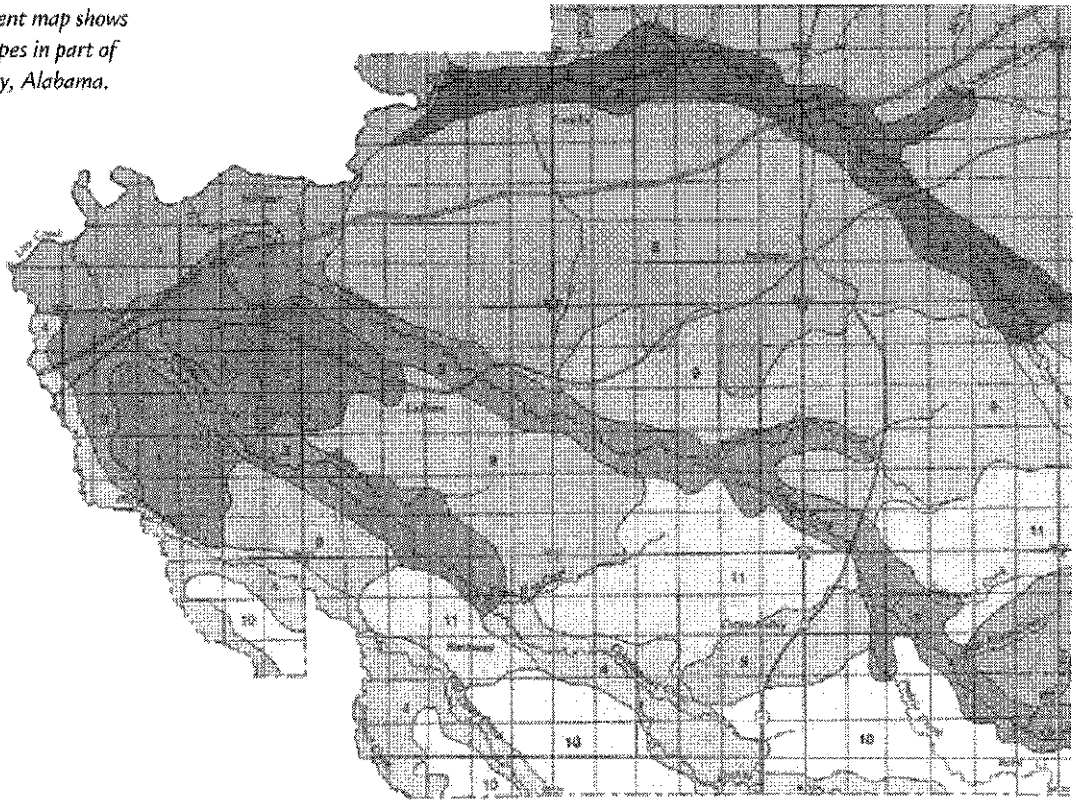
When soil scientists investigate the composition of soil in an area, they collect samples from many different locations. They organize all of their data on a map that shows where different soil types can be found. Such maps help compare the soil from one location, like the soil from the school garden, with soil in other locations.

There are thousands of different soils in the world. Scientists organize them into 12 major categories. In this activity, the soils found in the United States are grouped into 4 broad categories.

CHALLENGE

How does the soil in the school garden compare to the soil in other parts of the United States?

This government map shows general soil types in part of Macon County, Alabama.



MATERIALS

For the class

- **2 sets of 16 Soil Data Cards**
- **colored pencils (green, orange, brown, red)**

For each student

- **1 Student Sheet 7.1, "Mapping U.S. Soils"**

PROCEDURE

1. Work with your group to read the descriptions of the four major categories of soil on the next page.
2. Each person in your group will play the role of a scientist studying the soil from one area of the United States. Decide which person in your group will be the scientist who investigates soil from each of the following areas:
   - eastern United States
   - east-central United States
   - west-central United States
   - western United States
3. At the regional meeting, collect sample soil data by examining the Soil Data Cards provided by your teacher. Use colored pencils to fill in your region of the map on Student Sheet 7.1, "Mapping U.S. Soils." Use the Key on Student Sheet 7.1 which lists the color to use for each soil category.
4. Discuss the following questions about your region with other scientists from this region. Listen to and consider the ideas of others. If you disagree with others in your group, explain why you disagree.
   - What are some of the states in our region?
   - What is (or are) the most common soil type(s) in our region?
   - What shall we tell scientists from other regions about our findings?
5. Return to your original group and share the soil data that you collected. Use this data and colored pencils to fill in the map on Student Sheet 7.1.

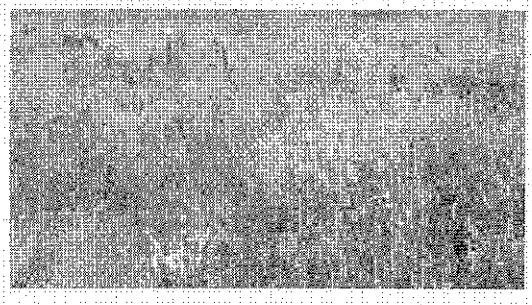
MAJOR SOIL CATEGORIES

DESERT

Desert soils form in places that do not have a lot of rainfall and that have high temperatures all year long. The soils tend to be dry, sandy, and contain a limited number of plants. These soils are easily moved by wind and water. Desert soils are light in color and have a firm consistence and gritty texture.

GRASSLAND

Grassland soils form in areas that have both wet and dry seasons but less overall rain than areas with forest soil. The top layer is rich in nutrients because a large amount of plant matter dies and decomposes in the soil. Grassland is good for farming. These soils are reddish brown, with a loose consistence and silky texture.

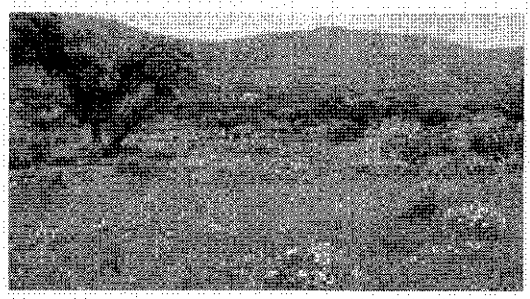


FOREST

Forest soils form in areas that have hot and cold seasons and receive enough rain year round to support a lot of tree growth. These soils are often good for farming. Forest soils are grayish brown to reddish brown due to small amounts of iron or aluminum. Forest soils have a loose consistence because they are very moist.

TROPICAL GRASSLAND

Tropical grassland soils are found in areas that are very warm all year long, with both wet and dry seasons, unlike tropical areas that are always wet. The soil tends to be weathered and greyish brown. Because of the large amount of fine particles in the soil, the texture is sticky.



6. Work with your group to locate the following three places on the map. Mark each with an "X" and label the map with their names.
   - Chris's school (Label it "Phoenix.")
   - Orlando, Florida (Label it "Orlando.")
   - Your school (Label it with the name of your city.)
7. Work with your group to identify U.S. soil patterns by discussing the following questions:
   - What is (or are) the most common type(s) of soil in the United States? How do you know?
   - What is (or are) the least common type(s) of soil in the United States?
   - What is the most common type of soil in your state?
   - What is the most common type of soil in Chris's state?
8. When you are done, compare your completed Student Sheet 7.1 with the transparency shown by your teacher.

ANALYSIS

1. Create a table that summarizes:
   - the four major soil categories found in the United States.
   - the composition of each of the soils.
   - the average weather conditions (temperature, rainfall, or seasons, for example) in which the soils are found.
2. Your cousin from central Nebraska calls you and says that the soil where she lives is the same as the soil in the school garden. Do you agree or disagree with your cousin? Explain your answer.

3. Compare the four soil categories with your data on Soil A, Soil B, and Soil C from the Activity 2 "Describing Soil Scientifically". What category of soil matches the soil in the school garden in Arizona, the garden in Florida, and the school yard in Michigan? Explain your answer.

INVESTIGATION

Some people think that soil is "food" for plants, but that is not true. Plants make their own food through a process called photosynthesis (foe-toe-SIN-thuh-sis). This food is stored in the plant as sugar or starch. Sugar and starch provide the plant with the energy it needs for growth.

Plants use certain chemicals from the soil. Because these chemicals also help the plant grow, they are called nutrients. Three important nutrients that plants need are nitrogen (NI-troh-jen), phosphorus (FOSS-for-us), and potassium (po-TASS-ee-um). When the soil does not contain enough of these nutrients, **fertilizers** containing these chemicals are sometimes added to the soil.

CHALLENGE

How does soil help plants grow?

The labels of both manufactured and organic fertilizers often show the levels of nutrients they contain. The three numbers seen on the front of each fertilizer refer to levels of nitrogen, phosphorus, and potassium.

MATERIALS

For each group of four students

- **1 piece of chart paper**
- **markers**

For each pair of students

- **1 Plant Puzzle (containing 5 pieces)**
- **6 Soil Cards**
- **3 Nutrient Cards**

For each student

- **1 Student Sheet 9.1, "Comparing Soils"**

PROCEDURE

Part A: Finding Missing Nutrients

1. Place all of the numbered Soil Cards face down on the table.
2. With your partner, put together the Plant Puzzle. This puzzle will tell you what plants need for growth.
3. Record what plants need for growth in your science notebook.
4. To imagine trying to grow a plant in a different type of soil, remove the Nutrient-Rich Soil Card from the Plant Puzzle.
5. Select a Soil Card from the face-down cards.
6. Place the Soil Card under the plant in the puzzle.
7. Record the Soil Card number and the nutrients this soil contains on Student Sheet 9.1, "Comparing Soils."
8. Use the Nutrient Cards to fill in any nutrients this soil is missing. Record the missing nutrients on Student Sheet 9.1.

9. Each kind of fertilizer may contain different amounts and proportions of nitrogen, phosphorus, and potassium. The plant in your puzzle requires equal amounts of each of these nutrients.
   a. Look at which nutrients this particular soil is missing. Compare the missing nutrients to the nutrient levels of different fertilizers in the table below.
   b. Select the best fertilizer for use with this soil.
      Hint: The best fertilizer provides more of the missing nutrients.
   c. Record your recommendation on Student Sheet 9.1.

Percentage of Nutrients in Fertilizers

Fertilizer	Nitrogen (N)	Phosphorus (P)	Potassium (K)
A	20	10	20
B	25	5	5
C	16	16	8
D	20	20	20
E	0	0	22
F	5	15	15

10. Repeat Steps 5–9 until you have examined all of the Soil Cards.

Part B: Making a Concept Map

11. Work with your group to create a list of at least 15 words related to soil from this unit. It may help to think about these questions:
    - What is soil?
    - What is the role of soils in plant growth?
    - What do plants need in order to grow?
    - Why are fertilizers used?

12. Discuss with your group how all of the words on your list are related to soil. Sort your list of words into 3–5 categories based on these relationships. For example, words such as *nitrogen, phosphorus,* and *potassium* could all be in one category because they are all chemicals that plants need to grow.

    Remember to listen to and consider the ideas of other members of your group. If you disagree with others in your group, explain why you disagree.

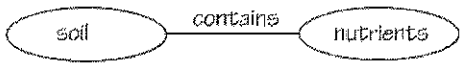
13. Identify words that can be used to describe each category. For example, *nitrogen, phosphorus,* and *potassium* could all be described as nutrients.

14. Work with your group to create a concept map for soil. Follow these steps:

    a. Write the word *soil* in the center of your paper and circle it.

    b. Place the words describing each category around the words *soil.* Circle each word.

    c. Draw a line between the word *soil* and each category. On each line, explain the relationship between the word *soil* and the category. For example:



    d. Repeat Steps 14b and 14c as you continue to add all of the words on your list to your concept map.

    e. Add lines to connect other related words. Explain the relationship between the words on the line.

15. Look at the concept maps created by the other groups. Observe similarities and differences between their maps and your own. Discuss your observations with other members of your group.

ANALYSIS

1. What do plants need to grow?
2. Describe the relationship among
   a. plants, soil, and nutrients.
   b. plants, soil, and fertilizers.
3. Sometimes plants are grown without soil, as shown below. These hydroponic (hi-druh-PON-ik) plants are grown by putting nutrients usually found in soil in the plant's water supply. Which is more important—soil or water—for plant growth? Why?

Hydroponic plants, like these strawberry plants, are grown without soil.

4. Do you think the school garden needs more nutrients? How do you think you could find out?
5. **Reflection:** How did constructing a concept map for soil help you understand more about soil?